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Nakayoshi et al.

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[54] **VALVE TIMING CONTROL DEVICE**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[6] **F01L 1/344**

[52] **U.S. Cl.** **123/90.17**; 123/90.31

[58] **Field of Search** ..... 123/90.15, 90.17, 123/90.19, 90.31; 74/568 R; 464/1, 2, 160

[56] **References Cited**

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5,666,914 9/1997 Ushida et al. 123/90.17

FOREIGN PATENT DOCUMENTS

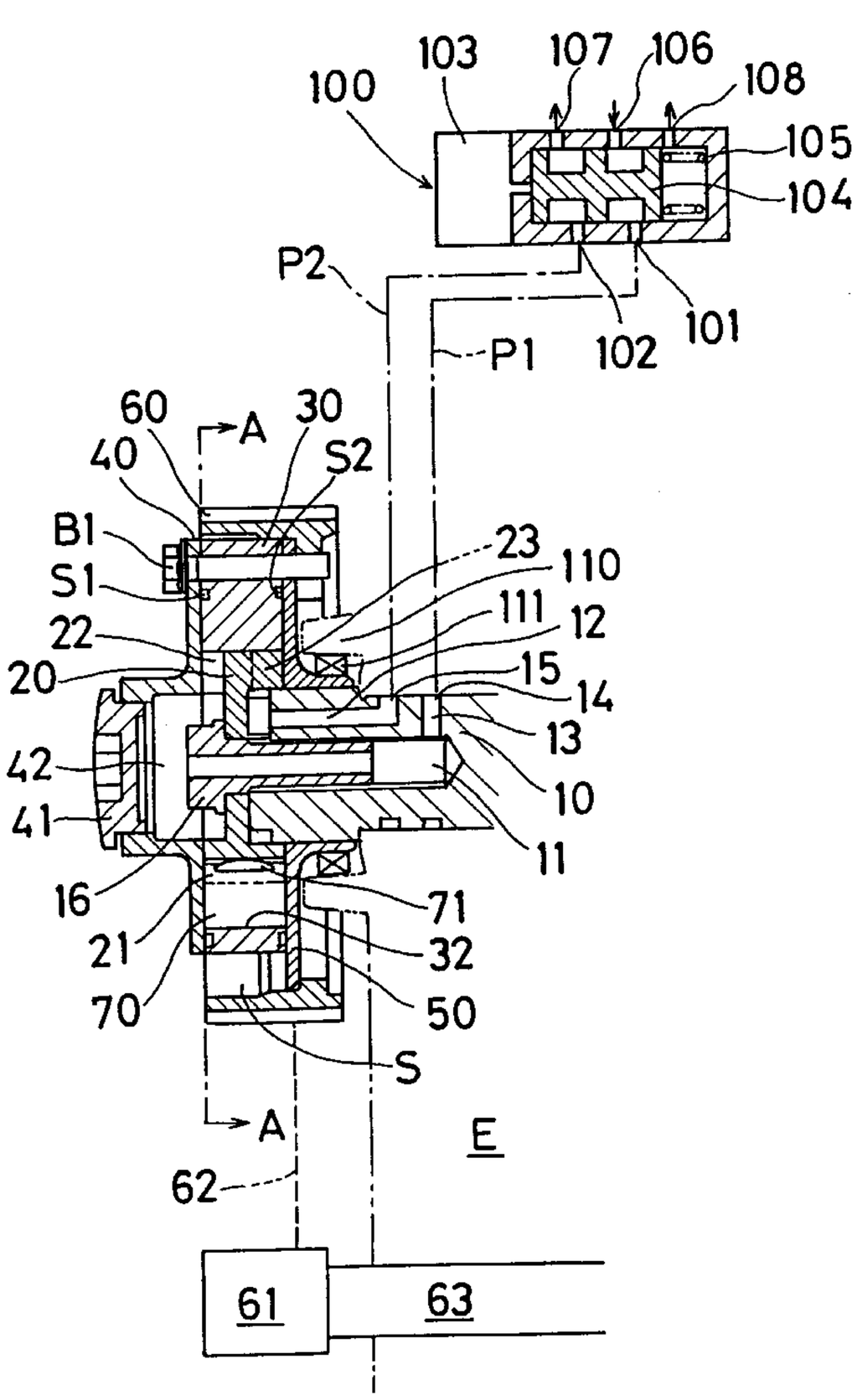
1-92504 4/1989 Japan .
2-50105 4/1990 Japan .
9-60508 3/1997 Japan .
10-47022 2/1998 Japan .

Primary Examiner—Weilun Lo
Attorney, Agent, or Firm—Hazel & Thomas, P.C.

[57] **ABSTRACT**

A valve timing control device for controlling the opening/closing timing of the intake valve or exhaust valve incorporates a valve opening/closing rotary shaft, a rotor provided on the rotary shaft, a timing pulley for receiving rotational power from a crank pulley through a timing belt, a rotation transmitting member provided within the timing pulley and mounted around the rotary shaft to rotate within a predetermined range, a plurality of vanes provided on the rotor or the rotation transmitting member, a fluid chamber formed between the rotor and the rotation transmitting member and separated into advancing chambers and delaying chambers by the vanes, a first fluid passage communicating with the advancing chambers, a second fluid passage communicating with the delaying chambers, and a cooling mechanism for cooling the rotation transmitting member and/or the timing pulley.

3 Claims, 3 Drawing Sheets



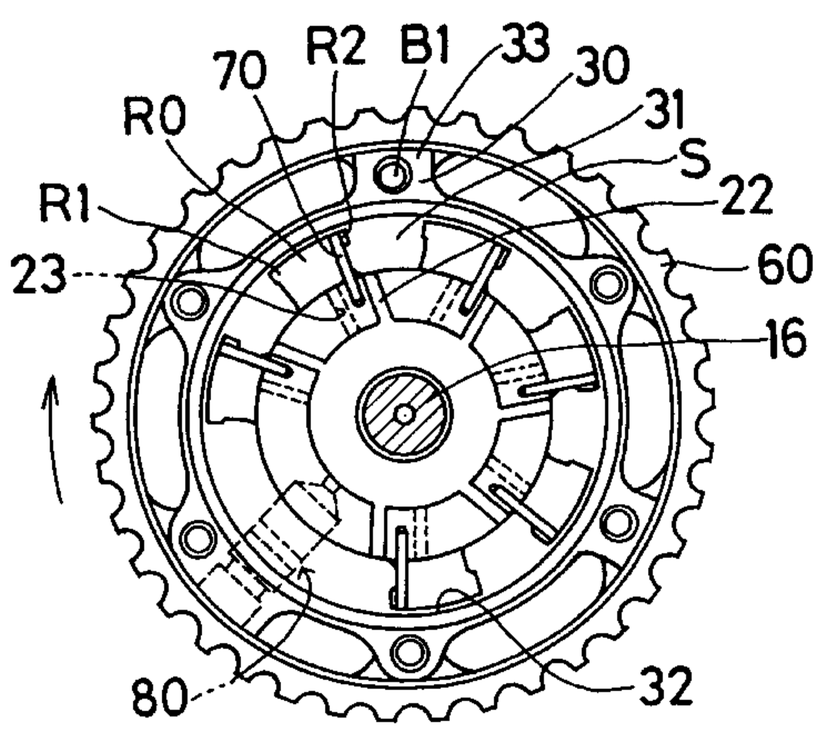


Fig. 1

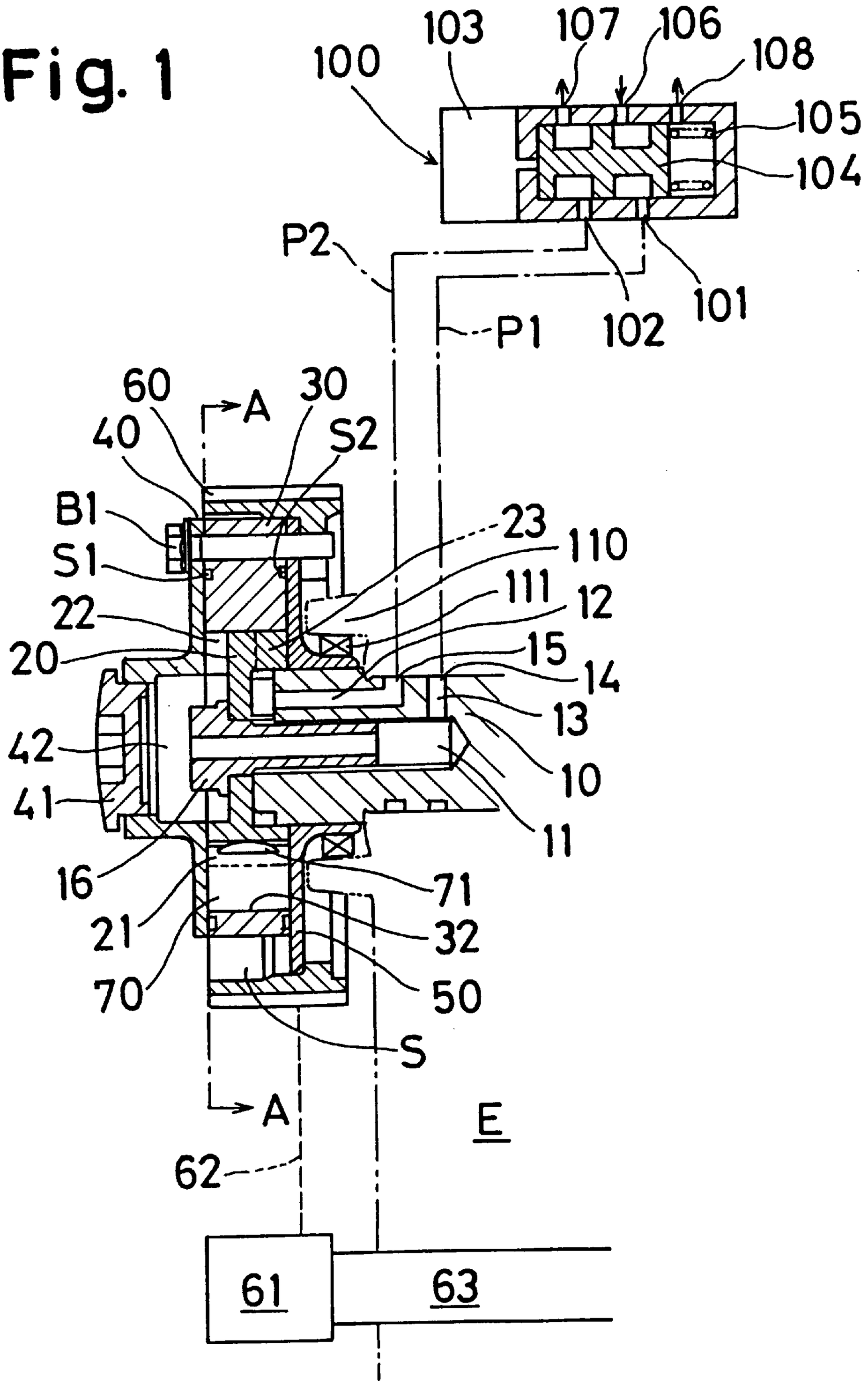

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Fig. 2

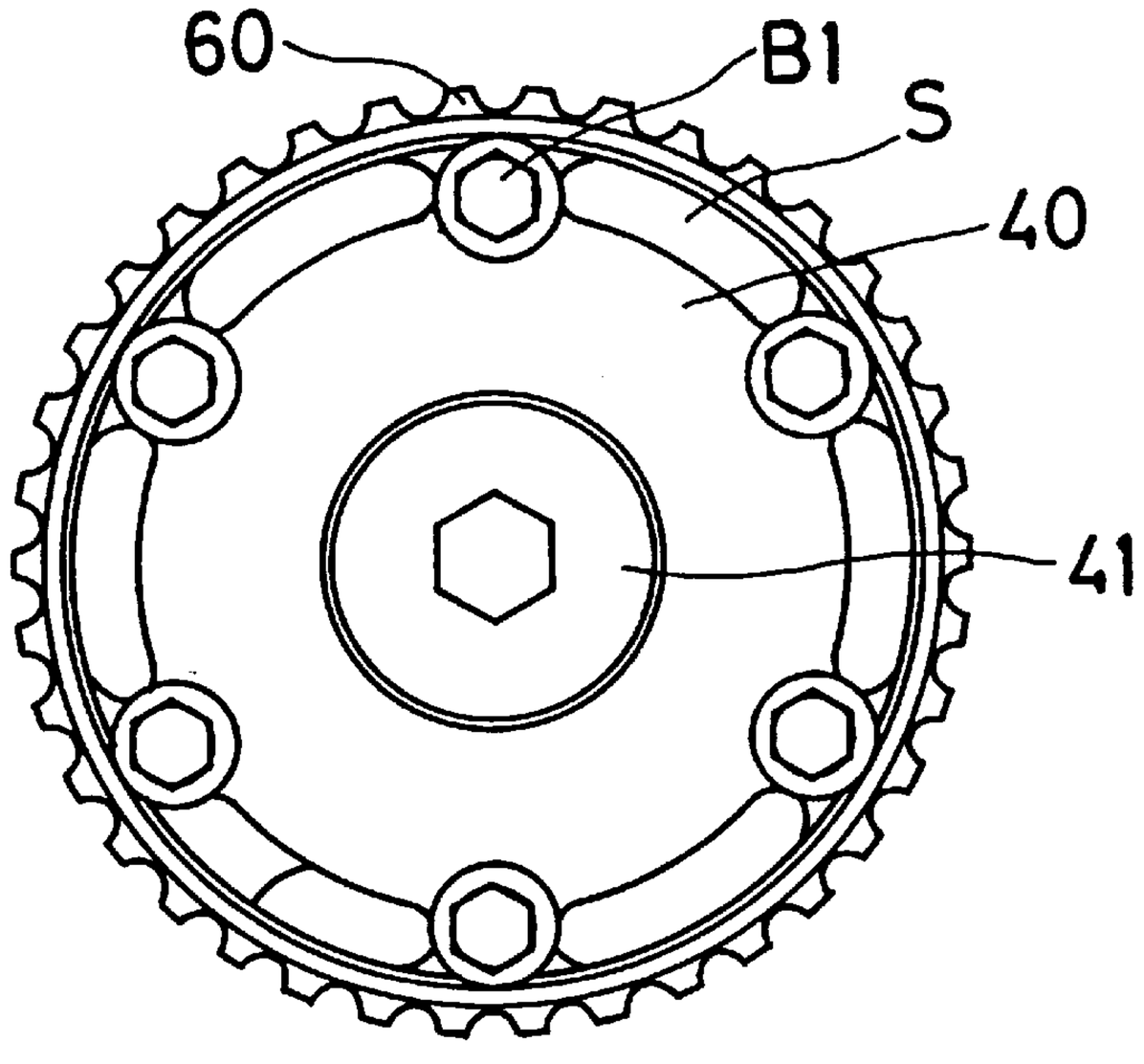


Fig. 3

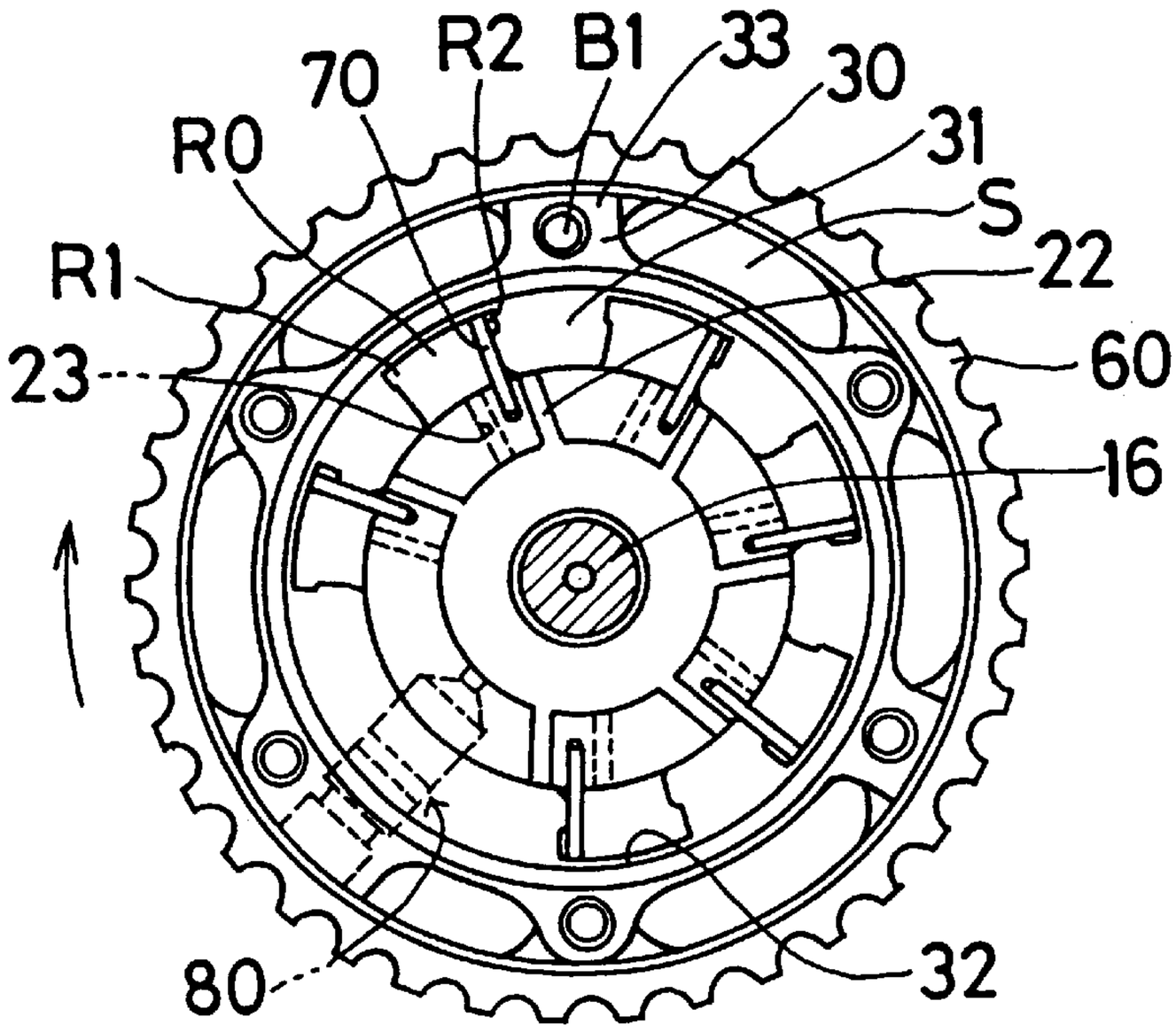
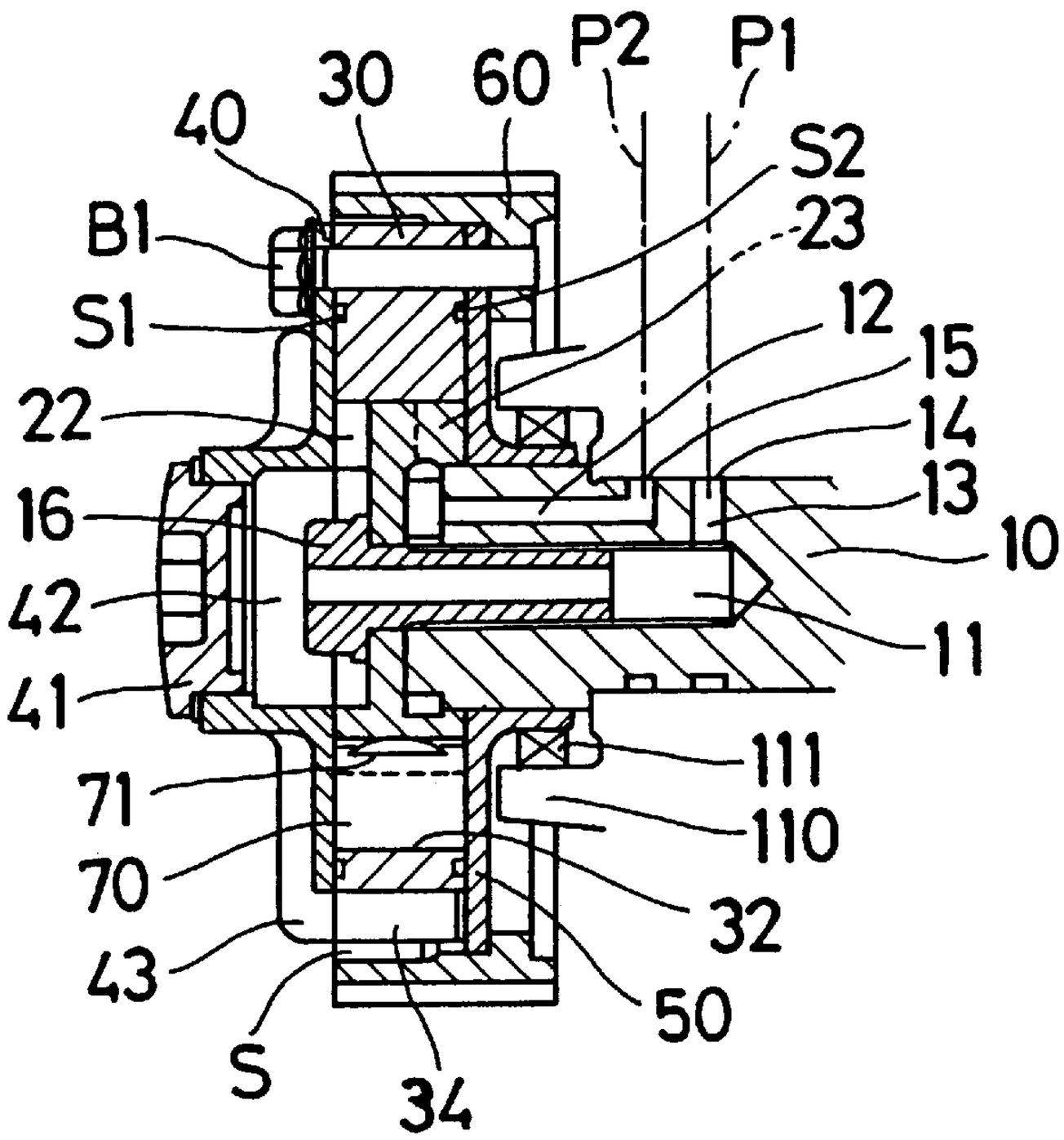


Fig. 4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P1
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S2
B1
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S1
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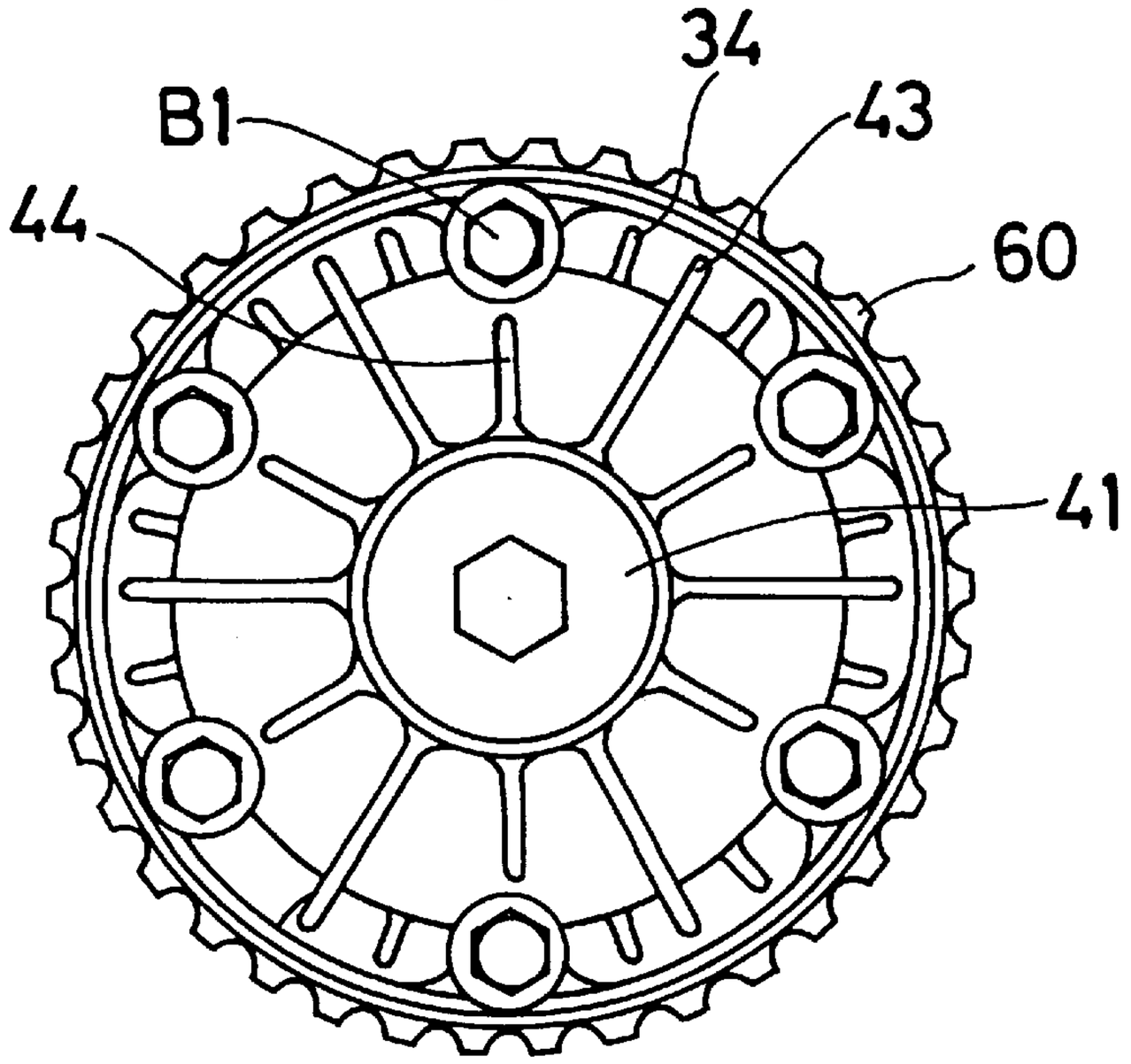
Fig. 5


34
B1
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VALVE TIMING CONTROL DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a valve timing control device to be used for controlling the opening/closing timing of an intake valve or an exhaust valve in a valve actuating mechanism of an internal combustion engine.

2. Description of the Related Art

In Unexamined Published Japanese Patent Application No. Hei 1-92504 or Unexamined Published Japanese Utility Model Application No. Hei 2-50105, for example, there is disclosed a valve timing control device of that kind comprising: a valve opening/closing rotary shaft rotatably assembled with the cylinder head of the internal combustion engine; a rotor integrally provided on the rotary shaft; a timing pulley for transmitting rotational power from a crank pulley through a timing belt; a rotational transmitting member integrally provided within the timing pulley, which is mounted around the peripheral surface of the rotary shaft, so as to rotate within a predetermined range for transmitting the rotational power from the crank pulley; a plurality of vanes provided on the rotor or the rotational transmitting member; a fluid chamber formed between the rotor and the rotational transmitting member and separated into advancing chambers and delaying chambers by the vanes; first fluid passages for feeding and discharging a fluid to and from the advancing chambers; and second fluid passages for feeding and discharging the fluid to and from the delaying chambers.

In the valve timing control device, as described in each of the above-cited patent applications, the rotational transmitting member includes an external rotor, a front plate and a rear plate. The fluid chamber is formed between the rotor and the external rotor and separated into advancing chambers and delaying chambers by the vanes. Working fluid is fed to or discharged from the advancing chambers and delaying chambers. The timing pulley is disposed outside of the external rotor.

The timing belt is located between the crank pulley and the timing pulley. The timing belt, the crank pulley and the timing pulley are all disposed in a timing belt case. The timing belt case is attached on the side of the cylinder block and on the front side of the cylinder head. When the internal combustion engine is driven, the temperature of the atmosphere inside the timing belt case reaches about 80 degrees centigrade. On the other hand, the working fluid, which is used as lubricating oil, reaches from about 120 degrees centigrade to 130 degrees centigrade, when the internal combustion engine is driven. In the valve timing control device, as described in each of the above-cited patent applications, the working fluid heats the rotational transmitting member and the timing pulley. This heat might damage the timing belt made of a resin or a rubber and shorten the lifespan of the timing belt.

SUMMARY OF THE INVENTION

The invention has been conceived to solve the above-specified problems. According to the invention, there is provided a valve timing control device for controlling the opening/closing timing of an intake valve or exhaust valve of an internal combustion engine comprising, a valve opening/closing rotary shaft rotatably assembled with the cylinder head of the internal combustion engine, a rotor integrally provided on the rotary shaft, a timing pulley for receiving rotational power from a crank pulley through a timing belt, a rotational transmitting member integrally provided within the timing pulley and mounted around the rotary shaft, so as to rotate within a predetermined range, a plurality of vanes provided on the rotor or the rotational transmitting member, a fluid chamber formed between the rotor and the rotational transmitting member and separated into advancing chambers and delaying chambers by the vanes, first fluid passages for feeding and discharging a fluid to and from the advancing chambers, second fluid passages for feeding and discharging the fluid to and from the delaying chambers, and a cooling mechanism for cooling the rotational transmitting member and/or the timing pulley.

Other and further objects, features and advantages of the invention will appear more fully from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal section schematically showing one embodiment of a valve timing control device according to the invention;

FIG. **2** is a side view showing an essential portion of FIG. **1**;

FIG. **3** is a section taken along line A—A of FIG. **1**;

FIG. **4** is a longitudinal section schematically showing another embodiment of a valve timing control device according to the invention; and

FIG. **5** is a side view showing an essential portion of FIG. **4**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One embodiment of the invention will be described with reference to the accompanying drawings.

A valve timing control device according to the invention, as shown in FIGS. **1** to **3**, is constructed so as to comprise a valve opening/closing shaft including a cam shaft **10** rotatably supported by a cylinder head **110** of an internal combustion engine E, and an internal rotor **20** integrally provided on the leading end portion of the cam shaft **10**; a rotational transmitting member mounted around the rotary shaft so as to rotate relative thereto within a predetermined range and includes an external rotor **30**, a front plate **40**, a cap **41**, a rear plate **50** and a timing pulley **60**. Six vanes **70** are assembled with the internal rotor **20**. A lock mechanism **80** is assembled with the internal rotor **20** and the external rotor **30**. The timing pulley **60** is constructed, as shown in FIG. **1**, to transmit the rotational power in the clockwise direction of FIG. **3** from the crank pulley **61** through a timing belt **62** made of resin or rubber. The crank pulley **61** is provided on a crank shaft **63** of the internal combustion engine E.

The cam shaft **10** is equipped with the well-known cam (although not shown) for opening/closing an intake valve or an exhaust valve (although not shown) and is provided therein with an advance passage **12** and a delay passage **11**, which extend in the axial direction of the cam shaft **10**. The advance passage **12** is connected to a connection port **102** of a change-over valve **100** via an annular passage **15** and a connection passage P**2**. On the other hand, the delay passage **11** is connected to a connection port **101** of the change-over valve **100** via a radial passage **13**, an annular passage **14** and a connection passage P**1**.

The change-over valve **100** is able to move the spool **104** rightward within FIG. **1** against the action of a spring **105** by energizing a solenoid **103**. The change-over valve **100** is so

constructed as to establish, when de-energized, communication between a feed port **106**, as connected to an oil pump (although not shown) to be driven by the internal combustion engine E, and the connection port **101**, and communication between the connection port **102** and an exhaust port **107** and further as to establish, when energized, the communication between the feed port **106** and the connection port **102** and communication between the connection port **101** and an exhaust port **108**. As a result, the working oil is fed to the advance passage **12**, when the solenoid **103** is energized, and to the delay passage **11** when the same is de-energized.

The internal rotor **20** is integrally fixed to the cam shaft **10** by means of a hollow bolt **16** and is provided with vane grooves **21** for mounting the six vanes **70** individually in radial directions. Further provided are passages **23** for feeding/discharging the working oil to and from advancing chambers R1, as defined by the individual vanes **70**, via the advance passage **12**; and passages **22** for feeding/discharging the working oil to and from delaying chambers R2, as defined by the individual vanes **70**, via the delay passage **11**. Here, each vane **70** is urged radially outward by a spring **71** (as shown in FIG. **1**) fitted in the bottom portion of the vane groove **21**. The lock mechanism **80** is able to engage between the internal rotor **20** and the external rotor **30**, where both of the internal rotor **20** and the external rotor **30** are synchronized in a predetermined phase. The predetermined phase is the most advanced position as shown in FIG. **3**. In this embodiment, the working oil under pressure in the advance passage **12** is able to cancel the engagement of the lock mechanism **80**.

In the inner circumference of the external rotor **30**, the external rotor **30** is assembled with the outer circumference of the internal rotor **20** so as to rotate within a predetermined range. To the two sides of the external rotor **30**, there are joined the front plate **40** and the rear plate **50** through seam members SI and S2. The external rotor **30** is integrally joined to the internal rotor **20** together with the timing pulley **60** by means of six bolts B**13**. With the front plate **40**, the cap **41** is assembled liquid-tightly to form a passage **42** for connecting the delay passage **11** of the cam shaft **10** and the passages **22** of the internal rotor **20**. In the external rotor **30**, on the other hand, there are six concave portions **32** forming fluid pressure chambers R**0** to accommodate the individual vanes **70** and adapted to be separated into the advancing chambers R**1** and the delaying chambers R2 by the individual vanes **70**.

As shown in FIGS. **2** and **3**, the external rotor **30** includes six outwardly directed projections **33** which are located on the outer peripheral surface of the external rotor **30** at equal intervals. Each projection **33** has a hole for inserting the bolt B**1**. On the other hand, both the front plate **40** and the rear plate **50** include six outwardly directed projections which are located on the peripheral surface thereof at the same intervals as the projections **33** of the external rotor **30**. Each projection has a hole for inserting a bolt B**1**. The bolts B**1** are inserted into the holes of these projections and screwed into the timing pulley **60**. Therefore, six cavities S are formed between the outer peripheral surface of the external rotor **30** and the inner peripheral surface of the timing pulley **60**.

In the valve timing control device constructed according to this embodiment, the change-over valve **100** in the state shown in FIG. **1** controls the working oil feeding from the change-over valve **100** to either the advancing chambers R**1** or the delaying chambers R**2**. When the working oil is fed from the change-over valve **100** to the advancing chambers R**1**, the phase is at the most advanced position (the vanes **70** are individually attached at the rotary directional side wall of the concave portions **32**) as shown in FIG. **3**. When the working oil is fed from the change-over valve **100** to the delaying chambers R**2**, the phase is at the most delayed position (the vanes **70** are individually attached at the anti-rotary directional side wall of the concave portions **32**).

Hence, the timing belt **62**, the crank pulley **61** and the timing pulley **60** are disposed into a timing belt case (not shown). The timing belt case is attached to the side of the cylinder block and on the front side of the cylinder head **100**. When the internal combustion engine E is driven, the temperature of the atmosphere inside the timing belt case is about 80 degrees centigrade. On the other hand, the working oil, which is used as lubricating oil, is from about 120 degrees centigrade to 130 degrees centigrade, when the internal combustion engine E is driven. In the high temperature of the atmosphere, the cavities S are disposed between the outer peripheral surface of the external rotor **30** and the inner peripheral surface of the timing pulley **60**. This provides the radiation area of the external rotor **30** and the timing pulley **60**. In addition, the heat transmitted from the working oil to the timing pulley **60** through the external rotor **30** is minimized. Therefore, the cavities S prevent the timing pulley **60** from being heated, thereby prolonging the lifespan of the timing belt **62** made of a resin or rubber.

FIGS. **4** and **5** illustrate another modified version of the preferred embodiment, in which a specific arrangement of a cooling mechanism is used. In FIGS. **4** and **5**, the same parts shown in FIGS. **1** to **3** are used with the same numerals. In this embodiment, there are a plurality of cooling fins **34** which are disposed on the outer peripheral surface of the external rotor **30**. Further, there are a plurality of cooling fins **43** and **44** which are arranged on the front side surface of the front plate **40**. As a result, the radiation area of the external rotor **30** and the front plate **40** is able to be increased by means of the fins **34**, **43** and **44**. The heat transmitted from the working oil to the timing pulley **60** through the external rotor **30** is minimized. Therefore, the fins **34**, **43** and **44** prevent the timing pulley **60** from being heated, thereby also prolonging the lifespan of the timing belt **62** made of a resin or rubber.

What is claimed is:

1. A valve timing control device for controlling the opening and closing timing of the intake valve or exhaust valve of an internal combustion engine, comprising;

a valve opening and closing rotary shaft rotatably assembled with a cylinder head of the internal combustion engine;

a rotor integrally provided on the rotary shaft;

a timing pulley for receiving rotational power from a crank pulley through a timing belt;

a rotational transmitting member integrally provided within the timing pulley and mounted around the rotary shaft, so as to rotate within a predetermined range;

a plurality of vanes provided on the rotor or the rotational transmitting member;

a plurality of fluid chambers formed between the rotor and the rotational transmitting member and separated into advancing chambers and delaying chambers by the vanes;

first fluid passages for feeding and discharging fluid under pressure to and from the advancing chambers;

second fluid passages for feeding and discharging fluid under pressure to and from the delaying chambers; and

means for preventing heat transfer between the rotation transmitting member and the timing pulley, wherein the

means including a plurality of peripherally spaced connecting elements fixedly connecting the timing pulley to the transmitting member and a cavity defined between the transmitting member, the timing pulley and the plurality of connecting elements, the cavity being further defined to extend in the axial direction of the rotary shaft.

2. A valve timing control device according to claim **1**, wherein the cavity is defined between an outer peripheral surface of the rotational transmitting member and an inner peripheral surface of the timing pulley.

3. A valve timing control device comprising:

a valve opening and closing rotary shaft rotatably assembled with a cylinder head of an internal combustion engine;

a rotor integrally provided on the rotary shaft;

a timing pulley for receiving rotational power from a crank pulley through a timing belt, and having a plurality of projections which are inwardly projected from an inner peripheral surface of the timing pulley and which are located at predetermined intervals;

a rotational transmitting member mounted around the rotary shaft so as to rotate within a predetermined range, and having a plurality of projections which are outwardly projected from an outer peripheral surface of the rotational transmitting member and which are located at the same intervals as the projections of the timing pulley;

a connecting member for connecting the projections of the timing pulley to the projections of the rotational transmitting member so as to integrally rotate;

a vane provided on the rotor or the rotational transmitting member;

a fluid chamber formed between the rotor and the rotational transmitting member and divided into advancing chamber and delaying chamber by the vane; and

a fluid supplying means for supplying fluid under pressure to at least a selected one of the advancing chamber and the delaying chamber.

* * * * *